SPECIAL REPORT ARLCB-SP-82006

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1981

R. D. Neifeld
Technical Publications and Editing Unit

April 1982

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER WEAPON SYSTEMS LABORATORY
BENET WEAPONS LABORATORY
WATERVLIET, N. Y. 12189

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REPORT DOCUMENTATION PAGE

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11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: April 1982
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a compilation of Benet Weapons Laboratory technical reports published during 1981.

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1. REPORT NUMBER: ARLCB-TR-81001	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
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	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): V. P. Greco	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, NY 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 32970672130, PRON No. 1A924411A1A
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18. SUPPLEMENTARY NOTES

Presented at the 67th Annual AES Conference & Exhibit of Industrial Finishing, Milwaukee, WI, 22-26 June 1980.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Electrodeposits
LASER
Surface Heating
Chromium
Surface Diffusion

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The use of the LASER as a tool to improve the properties of electrodeposits for wear and erosion resistance is introduced. The microstructures and microhardness of LASER treated electrodeposits of chromium (Cr) and duplex coatings of chromium over cobalt (Co) onto steel are shown. Cobalt as an underlay is shown to produce superior structures compared to chromium directly on steel which suffers from the formation of brittle phases at the chromium-steel interface.

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1. REPORT NUMBER ARLCB-TR-81002	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPUTATION SCHEMES FOR SENSITIVITY COEFFICIENT OF EXTERIOR BALLISTICS WITH VELOCITY SQUARE DAMPING		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen and Julian J. Wu		8. CONTRACT OR GRANT NUMBER(s)
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Presented at the 1980 Army Numerical Analysis and Computer Conference, NASA Ames Research Center, Moffett Field, California, 20-21 February 1980.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Ballistics with Drag
Sensitivity Coefficients
Target Hitting
Initial Velocity and Elevation Angle Correction
Computational Scheme
Iteration Procedure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The principal equation of exterior ballistics with velocity square damping term has been integrated analytically in obtaining the solution for tangential velocity in terms of the elevation angle and other parameters. Using the variational method, four equations are obtained. The first one is derived from consideration of terrain slope and the second one is determined by hitting the target. The third and fourth equations are variations of the range and
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20. Abstract (Cont'd)

elevation drag functions, respectively.

The computation involves integrals which can be evaluated analytically if the drag coefficient is relatively small. In simplifying the computational procedure we can assign the launch and impact slopes and then compute the drag functions and the terrain slope. However, this procedure is in reverse order because physically the terrain slope is known a priori the rounds are fired. If the terrain slopes and launch slopes are given first, an iteration procedure in computation is required to solve for the impact slopes. The sensitivity coefficients and the range ratios are then computed and plotted for various terrain slopes and launch slopes as the drag coefficients are varied.

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1. REPORT NUMBER ARLCB-TR-81003	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* REINFORCEMENT OF FeCrAlY WITH SILICON CARBIDE (CARBON CORE) FILAMENT		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) I. Ahmad, D. N. Hill, J. Barranco, R. Warenchak, and W. Heffernan		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

Published in Advanced Fibers and Composites for Elevated Temperatures edited by I. Ahmad and B. R. Noton, pp. 156-174; proceedings of symposium held at 108th AIME Annual Meeting, New Orleans, Louisiana, 20-21 February 1979.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Chemical Vapor Deposition
Diffusion Bonding
FeCrAlY Alloy
High Temperature Mechanical Properties
Metal Matrix Composites
Silicon Carbide Filament
Stress-to-Rupture
Tungsten Coating

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

In view of its high temperature stability (100 hr stress-to-rupture of 280 ksi at 2000°F), low density (0.115 lb.in.^{3}) and high elastic modulus ($60x10^{4}$ psi) silicon carbide filament (carbon core) is an attractive candidate as a reinforcement for high temperature matrix alloys. However, it reacts with most metals at elevated temperatures and must be protected with a suitable barrier coating. For FeCrAlY, tungsten was found to be a good barrier material. Therefore, 0.0005 in. thick coating of tungsten was
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20. Abstract (Cont'd)

applied to the filament by a continuous chemical vapor deposition process. The coated filament had 100 hr 2000°F rupture strength of 110-130 ksi. Composites of FeCrAlY containing about 30 v/o of the coated filament were fabricated using the diffusion bonding process and their tensile and stress-to-rupture properties were determined in the 1800°F - 2000°F range. While at room temperature the tensile strength of the composite was low, at elevated temperatures it approached values predicted by the rule of mixtures. At 1800°F, the 100 hr stress-to-rupture was 35 ksi. At higher temperatures, excessive coating-matrix interaction resulted in the degradation of the composite properties.

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1. REPORT NUMBER ARLCB-SP-81004	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Computer User Guide for IBM 4341		5. TYPE OF REPORT & PERIOD COVERED
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7. AUTHOR(s) J. Pascale R. Romano		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. DA Project. PRON No.
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

IBM 4341 Computer
Central Processor

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This guide provides an introduction to the IBM 4341 Computer, and associated operating system and describes in detail the facilities, services, procedures, and policies relating to its use.

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4. TITLE *(and Subtitle)* RESIDUAL STRESS REDISTRIBUTION CAUSED BY NOTCHES AND CRACKS IN A PARTIALLY AUTOFRETTAGED TUBE		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. L. Pu and M. A. Hussain		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A0215601A1A
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18. SUPPLEMENTARY NOTES

To be published in Journal of Pressure Vessel Technology.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Stress Intensity
Residual Stress
Stress Redistribution
Autofrettaged Tube
Fracture Mechanics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A simple method is provided for the computation of the redistribution of residual stresses and the stress intensity factors due to the introduction of notches and cracks in a partially autofrettaged tube. Numerical results of several crack and notch problems are obtained by the method of thermal simulation. These results are shown to be in excellent agreement with those obtained from the classical method of superposition. The new method based on thermal simulation
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20. Abstract (Cont'd)

is easier to apply and it avoids the singular stresses near the crack tip when the distributed crack face loading is used in the method of superposition.

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1. REPORT NUMBER ARLCB-TR-81006	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A CRITICAL REVIEW OF THE DRY FRICTION AND COMPRESSIBLE FLUID RECOIL/COUNTER-RECOIL CONCEPTS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) H. J. Sneck		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612603H181011 DA Project No. TL162603AH18 PRON No. 1A1AZC07NMLC
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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Recoil Mechanism
Dry-Friction Recoil System
Compressible Fluid Recoil System

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report reviews two new recoil systems as possible replacements for the conventional mechanisms currently in use on medium and large size cannon. One uses compressible fluid to dissipate energy in viscous friction and store elastic energy for counter recoil. The other uses coulomb or dry friction for dissipation of the recoil energy.

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: SERVICE SIMULATION TEST SYSTEM FOR KINETIC ENERGY PENETRATOR PROJECTILES	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): M. A. Scavullo and J. H. Underwood	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research and Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 41111629916, PRON No. 1A9289511A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: February 1981
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Presented at Second Charlottesville Conference on High Density Penetrator Materials, Foreign Science Technology Center, Charlottesville, Virginia, October 1980.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Simulation
Projector Launch
Fracture
Tensile Tests
Failure

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

During the launch of a high density penetrator round the sabot pulls the penetrator through the gun tube with a given acceleration. This causes a tensile stress in the penetrator which is proportional to the mass of the unsupported rear end of the penetrator times the acceleration. This tensile stress is a maximum at the rear of the sabot near the location of the rearmost

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20. Abstract (Cont'd)

groove which interconnects the sabot and penetrator. A simulation of this loading can be achieved by a tensile test in which the penetrator is loaded through its grooves. In this paper we will discuss the design of the tensile test apparatus and the preliminary results achieved. The test system can be used for comparisons of various designs, materials, coatings, and environmental effects.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81008	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A PHOTOELASTIC STUDY OF STRESSES IN SINGLE-GROOVE CONNECTIONS OF THE SAME MATERIAL		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Y. F. Cheng		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0 PRON No. 1A1281501A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE February 1981 13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Groove Connections
Photoelasticity
Maximum Fillet Stresses
Contact Stresses
Stress Concentrations

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report describes a three-dimensional photoelastic study on stresses in single-groove connections of the same material. Two groove profiles were investigated; namely, the British standard buttress and the new profile. Boundary stresses, interior stresses, and contact stresses were determined. Shear-difference method was used and the procedure of the method was outlined.

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20. Abstract (Cont'd)

Appropriate checks for the accuracy of the results were made. Heywood's empirical equation for calculating maximum fillet stress in loaded projections was reviewed. It was found that the British standard buttress is stronger than the new profile and that the Heywood's equation is not applicable in our problem. Further work on multi-groove connection is in progress.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-SP-81009	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) POSTURE REPORT - FY 1980		5. TYPE OF REPORT & PERIOD COVERED Final 1 Oct 79 thru 30 Sept 80
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Coordinated by: Plans and Resources Section Benet Weapons Laboratory		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. N/A DA Project. N/A PRON No. N/A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE March 1981
		13. NUMBER OF PAGES 75
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents an overview of the most important technical contributions and programs in research technology, weapons development, and engineering support for cannon technology.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81010	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* THERMAL AND STRUCTURAL ANALYSIS OF THE EFFECTS OF CHLORINE IMPURITIES ON PRESSURIZED CADMIUM SULFIDE		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. J. Cote, G. P. Capsimalis, and C. G. Homan		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A0215601A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE March 1981 13. NUMBER OF PAGES 13
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

Submitted for publication to Applied Physics Letters.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Differential Scanning	Temperature Effects
Calorimetry	Cadmium Sulfide
X-Ray Diffraction	Pressure Effects

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Anomalous large diamagnetism ($\chi \sim 0.25/4\pi$ cgs units) and large positive magnetism ($\chi_v \sim +10^{-4}$ cgs units) have recently been reported in pressure quenched CdS polycrystalline samples by Homan and MacCrone. These effects were shown to be sample material source dependent, and as a first step toward characterizing these samples, we compared the thermal and structural properties of various CdS samples before and after pressurization. Samples

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20. Abstract (Cont'd)
containing up to 6 wt % Cl were prepared by precipitation from a chloride containing aqueous bath. We find that (i) Cl impurities are probably present in the form of a complex which can decompose on heating to CdS + $CdCl_2$, (ii) melting of a portion of the samples containing high levels of Cl occurs at 535°C and is attributed to the eutectic temperature of the CdS + $CdCl_2$ mixture, and (iii) heating beyond 535°C produces complete volatization of the $CdCl_2$ component. The results on samples prepared by mixing of CdS and $CdCl_2 \cdot H_2O$ were examined and found to have similar thermal behavior. The cadmium sulfide used in the previous magnetization study was examined and, based on the similarities in the thermal and structural properties, we conclude that the samples which exhibit the anomalous magnetic effects were also prepared by precipitation. In agreement with earlier studies, metastable phases are observed after various pressurizations to above 4.0 GPa.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-81011
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: STUDY OF EROSION RESISTANT MATERIALS FOR GUN TUBES PART II: TANTALUM COATED LINERS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): R. L. Cullinan, G. D'Andrea, and P. Croteau

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
US Army Armament Research and Development Command
Benet Weapons Laboratory, DRDAR-LCB-TL
Watervliet, NY 12189

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 64366280071212
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11. CONTROLLING OFFICE NAME AND ADDRESS:
US Army Armament Research and Development Command
Large Caliber Weapon Systems Laboratory
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13. NUMBER OF PAGES: 50

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Gun Tube Erosion
Shrink-fit Liners
Bore Plating
Tantalum Coatings
20 mm M24A1 Gun
Erosion Protection

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The major criteria for the condemnation of gun tubes is based on the excessive erosion of the bore which results in loss of range and accuracy. Gun tube erosion is caused by severe thermal, mechanical, and chemical factors interacting during the firing cycle. One approach to minimize erosion is to line gun barrels with wear resistant materials. This work introduces tantalum
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20. Abstract (Cont'd)

coated steel liners to reduce excessive bore erosion. Firing tests conducted in the 20 mm M24A1 gun system compare the Ta/steel with steel and chromium plated steel liners subjected to the same test conditions. Preliminary results indicate that the Ta/steel combination reduces erosion in the 20 mm gun system. Future work calls for adapting the Ta/steel liner concept to large caliber gun tubes.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81012	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* THE CORRELATION OF FRACTURE TOUGHNESS WITH CHARPY V-NOTCH IMPACT TEST DATA		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. Tauscher		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.7588 PRON No. M1-7-P2913-M11A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE March 1981 13. NUMBER OF PAGES 72
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Barsom-Rolfe Correlation
Charpy Impact Test
Correlation
Linear Regression
Plain-Strain Fracture Toughness

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Fracture toughness data is compared with the Charpy V-notch impact data. The applicability of various regression models for showing the relationship of K_{Ic} with other mechanical properties is examined for gun steel. The types of material were classified by steel maker, type of forging, and location within the tube. It was concluded that, of the models examined, $K_{Ic}^2 = 5\ CVN\ \sigma_{ys} - .25\ \sigma_{ys}^2$, the Barsom-Rolfe correlation, provided the best correlation of K_{Ic} with mechanical property data. However, even then, the prediction of K_{Ic} was only within 6 - 18 percent of the measured value.

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1. REPORT NUMBER: ARLCB-TR-81013	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: MAIN ARMAMENT CONCEPTS FOR A NEAR TERM FUTURE MAIN BATTLE TANK	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): John K. Jorczak	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 612603.H1.80111 DA Project No. 1L162603AH18 PRON No. 1A-0-2ZB01-0-NMLC
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, N.J. 07801	12. REPORT DATE: March 1981 13. NUMBER OF PAGES: 43
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Integral Weapon Feeder
Telescoped Round

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This study was undertaken to develop various armament concepts and to define envelope configurations for near term future combat fighting vehicles (primarily the XM-1 successor). Ammunition, weapon and vehicle interface were main considerations from a broad spectrum in assessing concept growth potential.

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1. REPORT NUMBER ARLCB-MR-81014	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* AN IN-PROCESS THICKNESS DETERMINATION DURING ELECTROPLATING OR ELECTROPOLISHING BY THE ULTRASONIC PULSE-ECHO TECHNIQUE		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. Frankel W. J. Korman G. C. Capsimalis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, N.Y. 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A0215601A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE April 1981 13. NUMBER OF PAGES 3
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18. SUPPLEMENTARY NOTES

Published in 1980 Ultrasonics Symposium Proceedings, November 1980.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Electroplated Thickness
Electroplating
Electropolished Thickness
Time Measurement
Ultrasonics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The transit time change of an echo of an ultrasonic echo train is used to determine the thickness of electroplated chromium on a steel substrate and the change of thickness of the steel substrate during the electropolishing or surface removal operation.

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1. REPORT NUMBER: ARLCB-TR-81015	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: COMPUTER CONTROLLED ULTRASONIC INSPECTION OF CANNON TUBES	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Mark Johnson	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research and Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 53970M63500; PRON No. 1A925155GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: April 1981
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Ultrasonics
Minicomputer
Nondestructive Testing
Fatigue Cracks
Cannon

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An automated system for ultrasonically inspecting cannon tubes during fatigue testing has been developed. The tubes are inspected for cracks growing inward from the outer surface toward the tube center, measuring the depth, length, and angular position of each crack detected. The system uses a minicomputer to control the test equipment and process the results. The computer is
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20. ABSTRACT (Cont'd)

interfaced with a device that mechanically positions an ultrasonic probe and with an ultrasonic flaw detector capable of supplying it with inspection data upon request. The computer directs the probe inside the breech end of a cannon and collects the data for immediate analysis. The results of the inspection, including plots of crack location and crack growth, are printed on a teletype.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81016	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* BASIC MECHANICS OF DE BANGE OBTURATOR SPLIT RING PRESTRESSING		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) D. F. Finlayson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory, ARRADCOM Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 738017.C30Q70191CG PRON No. M179Q761M11A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE April 1981 13. NUMBER OF PAGES 23
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

De Bange Obturator
Split Ring
Prestress
Elastic-Plastic Deformation

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

An analysis is presented to show the relationship between the maximum obtainable residual shear force in a split ring preform and the prestressing parameters (included angle between fixture grips and total angle of twist). Also included is an analysis of the section depth of the ring that is required to provide sufficient material for the finish machining operation. Application of the formulas derived would require the quantification of certain parameters by either experimental or numerical methods.

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1. REPORT NUMBER: ARLCB-TR-81017	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: EVALUATION OF MODIFIED BORE EROSION GAGE	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): G. Capsimalis, R. Williams, and G. D'Andrea	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 53970M63500, PRON No. 1A9241561A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: May 1981
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Bore Erosion Gage
Rifling Profile Plotting
105 mm M68 Gun Tube

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A bore erosion gage developed earlier (Krupski and Audino, WVT QA-7701 (1977)) for monitoring the coating thickness and erosion of the 105 mm M68 in the region up to 40 inches from the origin of rifling has been modified, and the problem of the lack of responsibility of radius measurements along the bore circumference has been successfully eliminated. Test data and statistical analysis of the results have demonstrated that the modified gage can measure

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20. ABSTRACT (CONT'D)

the relative change in the bore radius with an accuracy of ± 0.005 inch. The statistical accuracy can be further improved by increasing the number of data points.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81018	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* FATIGUE AND FRACTURE TESTS OF GAS BOTTLE MATERIAL		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. H. Underwood and J. J. Zalinka		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 691000H180021 PRON No. 1A0271951A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1981 13. NUMBER OF PAGES 24
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18. SUPPLEMENTARY NOTES

Prepared by Benet Weapons Laboratory, US Army ARRADCOM, under contract to NASA Langley Research Center.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fracture
Fatigue
Fatigue Life
Cylinder

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A program of nondestructive inspection, mechanical tests, and fracture mechanics tests was performed on a high pressure air storage bottle. The tests were planned to provide the basis of fracture mechanics life analysis of gas bottles in their service environment. This report describes the procedures and results and gives a preliminary analysis of the results.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81019	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* NUMERICAL PREDICTION OF RESIDUAL STRESSES IN AN AUTOFRETTAGED TUBE OF COMPRESSIBLE MATERIAL		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 DA Project No. 1T161101A91A PRON No. 1A1281501A1A
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18. SUPPLEMENTARY NOTES

Presented at 1981 Army Numerical Analysis and Computer Conference, Huntsville, Alabama, 26-27 February 1981.
Published in proceedings of the conference.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
Elastic-Plastic Deformation
Residual Stress
Autofrettaged Tube
Finite-Difference Method

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*
The residual stresses in an autofrettaged tube of compressible material are obtained by a new finite-difference approach. The tube is assumed to obey the von Mises' yield criterion, the Prandtl-Reuss flow theory and the isotropic-hardening rule. In order to test the accuracy of the computer program, a convergence study for a nearly incompressible tube has been made and compared with the exact solution as well as the simulated results for residual stresses in an incompressible tube.

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1. REPORT NUMBER: ARLCB-TR-81020	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: SUPERCONDUCTIVITY IN PRESSURE QUENCHED CADMIUM SULFIDE AT 77 K	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): C. G. Homan (BWL), K. Laojindapun (RPI), and R. K. MacCrone (RPI).	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011, PRON No. 1A1283121A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: May 1981
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18. SUPPLEMENTARY NOTES

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Cadmium Sulfide
Diamagnetism
Pressure Quenched
Superconductivity

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Observations of magnetic field induced collapse of Meissner sized diamagnetism with a coincident decrease in electrical conductivity in pressure quenched CdS material at 77 K are reported. These results are consistent with the existence of superconducting regions in the specimens at this temperature.

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1. REPORT NUMBER ARLCB-MR-81021	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A FOUR POINT BENDING EXPERIMENT		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. V. Milligan and V. J. Olmstead		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 32111600116 PRON No. T196935802NMAE
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1981
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14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Straightening
Deflections
Strains
Gun Tubes

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report presents data obtained in a four point bend experiment on a 105 mm M68 rotary forged gun tube. The four point bending was accomplished using a standard hydraulic straightening press fitted with a two point loading device designed and fabricated by the Benet Weapons Laboratory Engineering Support Branch. Strains were measured at several points on the surface in a circumferential plane using standard foil type resistance gages and standard strain

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20. ABSTRACT (CONT'D)

readout equipment. Deflections at mid-span were measured with a rotary ten turn potentiometer. Load strain and load deflection curves are presented and compared with theory. The agreement is quite good. The difference between theory and experiment probably can be attributed to the larger diameter of the tube nearer the breech end which could contribute to greater stiffness. Maximum strains were less than 1.4 percent and are quite low compared to those expected in three point bending. The experiment shows a good possibility of using four point bending to eliminate the need for hot straightening.

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1. REPORT NUMBER: ARLCB-TR-81022	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: A RATIONAL FUNCTION APPROXIMATION FOR THE INTEGRATION POINT IN EXPONENTIALLY WEIGHTED FINITE ELEMENT METHODS	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Joseph E. Flaherty	8. CONTRACT OR GRANT NUMBER(s): Grant No. AFOSR 80-0192.
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H5710011 DA Project No. 1L161102BH57 PRON No. 1A1235821A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE: June 1981
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18. SUPPLEMENTARY NOTES

To be published in the International Journal for Numerical Methods in Engineering. This research was partially sponsored by the U.S. Air Force Office of Scientific Research, Air Force Systems Command, U.S.A.F. The U.S.
(CONT'D ON REVERSE)

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Convection-Diffusion Problems
Exponential-Weights
Finite Element Method
Rational Approximations

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A rational function is presented for approximating the function $f(z) = \coth z - 1/z$ that appears in several exponentially fitted or weighted finite difference and finite element methods for convection-diffusion problems. The approximation is less expensive to evaluate than $f(z)$ and provides greater accuracy than the doubly asymptotic approximation when $z = 0(1)$.

18. SUPPLEMENTARY NOTES (Cont'D)

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1. REPORT NUMBER: ARLCB-TR-81023	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): THE EFFECT OF PREBORE QUENCH TIME ON THE DEPTH AND UNIFORMITY OF HARDENING IN 105mm M68 GUN TUBE FORGING	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. Passmore, D. G. Baldrey	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research and Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, N.Y. 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3297.06.7588; PRON M1-7-P2913-(01)-M1-1A
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Quench
Spray Quench
Bore Quench
Hollow Tube Forging
Hardenability
8620 Steel
High Strength Steel

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

At Watervliet Arsenal, the quenching of hollow steel gun tube forgings from the austenitizing temperature has commonly involved a combination of bore quenching (I.D.) and spray quenching (O.D.). The bore quench is generally initiated prior to the start of the O.D. spray quench. This is called a prebore quench. This work evaluated the effect of quench time on the depth and uniformity of hardening in 105mm M68 gun tube forgings. (The prebore quench times were varied from 0 to 150 sec. in this investigation.)

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20. ABSTRACT (Cont'd)

Cooling rates in the tube wall for various prebore quench times were determined by welding sections of AISI 8620 steel to the breech and muzzle ends of the tube. The hardness gradient through the tube wall was used to determine cooling rates at 1300°F from the known relationships between end-quench hardenability curves and Jominy test bar cooling rates. The minimum cooling rates, at 1300°F, varied from 4°F/sec. to 10°F/sec. at the muzzle end of the tube. The point of minimum hardness (slowest cooling rate) moved toward the O.D. of the tube as the prebore quench time increased.

The minimum cooling rates resulting from the prebore quench times used in this experiment are sufficient to exceed the critical cooling rate for gun steel. As a result, the prebore quench time in the range of 0-150 seconds has no effect on the depth of uniformity of hardening in 105mm M68 gun tube forgings.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-81024	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: A COMPARISON OF THREE POINT AND FOUR POINT LOADING IN ELASTIC-PLASTIC BENDING OF BEAMS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): R. Vincent Milligan	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 612105H840011; DA Project No. 1L162105AH84; PRON No. 1A0217131A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: June 1981
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Beams
Straightening
Bending
Elastic-Plastic Analysis

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A comparison between the maximum deflections resulting from beams symmetrically loaded into the elastic-plastic region is presented for the case of three and four point bending. The results indicate that significantly larger deflections can be obtained for the case of four point bending while keeping the maximum fiber strains approximately the same. It appears that using the four point bending approach holds certain advantages in straightening operations for the
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20. ABSTRACT (CONT'D)

removal of permanent deflections with the possible elimination of hot straightening in some instances. The concept of distribution of plastic deformation is put forth as a possible explanation of the advantage of one method over the other.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81025	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* MOMENT-STRAIN RELATIONSHIPS IN ELASTIC-PLASTIC BENDING OF BEAMS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. V. Milligan		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612105H840011 DA Project No. 1L162105AH84 PRON No. 1A0217131A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1981 13. NUMBER OF PAGES 23
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Bending
Strain
Elastic-Plastic Deformation
Beams

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Theoretical expressions for bending moment versus depth of elastic-plastic interface for both rectangular, tubular, and solid circular beams are developed. Theoretical expressions for strain as a function of geometry and depth of elastic-plastic interface for each type of cross section are derived. The possibility of a strain singularity occurring as the elastic-plastic interface approaches the neutral axis is pointed out. The assumption that "planes remain

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20. Abstract (Cont'd)
plane" is examined. Experimental data is presented which supports the assumption. The basis for determining residual or permanent strains and expressions for their calculation are given. Finally a brief section of strain-curvature relationships is presented.

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1. REPORT NUMBER: ARLCB-TR-81026	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: REGENERATIVE LIQUID PROPELLANT GUN TECHNOLOGY	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Richard G. Hasenbein	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 612603H 180011, PRON No. 1A-8-AZ823-NMLC
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: June 1981
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Liquid Propellants
Liquid Propellant Guns
Regenerative Liquid Propellant Guns
Otto Fuel II
Ignition
Combustion
Combustion Instability

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A 40 mm Regenerative Injection Liquid Propellant Test Fixture has been designed, manufactured, and tested under the direction of Benet Weapons Laboratory, a division of the Large Caliber Weapon Systems Laboratory (LCWSL) of the U.S. Army Armament Research and Development Command (ARRADCOM). The objective was to develop a regenerative liquid propellant gun (RLPG) technology base within the ARRADCOM community and to investigate the ballistic
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20. ABSTRACT (CONT'D)

reproducibility of RLPG's in a 40 mm caliber.

A description of the fixture hardware, operation, and testing is provided. Critical areas which were identified and dealt with included material compatibility of sliding parts, projectile shot start pressure, ignition delay, combustion instability, and piston damping.

Considerable effort was expended in identifying and dealing with an acoustic combustion instability in the first tangential mode. The remedial approach which attenuated the instability was to machine five circumferential grooves on the face of the regenerative piston in the region of the injectors. This had the effect of simultaneously providing baffles and altering the injection "spray". The results show that although combustion instability is possible in an RLPG environment, it can be dealt with simply by using mechanical devices which are a direct extension of existing liquid propellant rocket technology.

Recommendations for future testing using this fixture are included.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* STRESS INTENSITY FACTORS FOR RADIAL CRACKS IN A PARTIALLY AUTOFRETTAGED THICK-WALL CYLINDER		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. L. Pu and M. A. Hussain		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A0215601A1A
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18. SUPPLEMENTARY NOTES

Presented at Fourteenth National Symposium on Fracture Mechanics, UCLA, Los Angeles, CA, 29 June - 1 July 1981.
To be published in ASTM Special Technical Publication.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Stress Intensity Factors
Multiple Cracks
Thick-Wall Cylinder
Quadrilateral Isoparametric Element
Weight Function
Load Relief Factor
Fracture Mechanics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Using a finite element method and thermal simulation, stress intensity factors are determined for a uniform array of equal depth radial cracks emanating from the internal boundary of a pressurized, autofrettaged thick-wall cylinder.

Computations of the stress intensity factors by methods of load relief and weight function are also examined. The combination of finite elements and

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20. ABSTRACT (CONT'D)

weight functions is found very effective and is used in this report for multiple-radial cracks in a partially autofrettaged tube.

Extensive numerical results are presented for a cylinder having an external diameter twice that of the internal diameter. It is shown that the autofrettaged tube with two diametrically opposed cracks remains, in general, the weakest configuration. For more than two cracks, the higher the number of cracks is, the smaller the stress intensity factor will be.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81028	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* STRUCTURAL ANALYSIS OF A KINETIC ENERGY PROJECTILE DURING LAUNCH		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. A. Pflegl, J. H. Underwood, and G. P. O'Hara		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 4111.16.2991.0 PRON No. 1A-9-39362-0
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE July 1981 13. NUMBER OF PAGES 18
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Penetrator
Sabot
Stress
Fracture

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This paper presents the results of a three phase effort to quantify the structural integrity of a long rod kinetic energy penetrator projectile during launch. The first phase used the finite elment method to investigate the two body problem of penetrator and sabot during peak launch loads. This portion of the analysis considered the effect of pressure loading, body forces, and different moduli to determine an estimate of the stresses present in the
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20. ABSTRACT (CONT'D)

penetrator and sabot - particularly along the intersection between the two. These stresses were then used to determine the load transfer between the penetrator and sabot.

The second phase of the effort applied the load transfer from phase one to a detailed finite element model of the thread-like lugs of the penetrator in order to determine the stress concentrations in the notch root area between the lugs. This portion of the work took into account the geometry, material properties, and load transfer of the lugs. The resulting stresses due to the shearing and bending loads and contact friction were analyzed to determine the location and magnitude of the largest tensile stresses at the surface of the lug root.

The value of maximum tensile stress in the root of the penetrator lugs was then used in a fracture mechanics analysis to determine a critical flow size which would cause brittle fracture. Using fracture toughness measurements from depleted uranium penetrator materials, critical flaw sizes were calculated and used to determine the likelihood of failure during launch and to formulate NDT inspection standards.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81029	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* LOW FREQUENCY INDUCTION HEATING OF LARGE DIAMETER STEEL PREFORMS FOR ROTARY FORGING		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) David Concordia		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3291.06.7328 PRON No. M7-4-P4727-M7-1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE July 1981 13. NUMBER OF PAGES 42
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Induction Heating
Magnetic Field
Magnetic Flux
Preforms
Rotary Forge

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Part I of this report surveys the basic theory of induction heating and heat flow in an inductively heated steel cylinder. Part II describes an induction heating system now in use at the Watervliet Arsenal, and applies the theory of Part I to this system.

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1. REPORT NUMBER ARLCB-SP-81030	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1980		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. D. Neifeld		8. CONTRACT OR GRANT NUMBER(s).
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE July 1981 13. NUMBER OF PAGES 113
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Benet Weapons Laboratory
Technical Publications
Bibliography
Abstracts
Document Control Data

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a compilation of Benet Weapons Laboratory technical reports published during 1980.

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1. REPORT NUMBER ARLCB-TR-81031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* NUMERICAL SOLUTION TO BEAM VIBRATIONS UNDER A MOVING COUPLE		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. J. WU		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 PRON No. 1A1283121A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE August 1981 13. NUMBER OF PAGES 29
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18. SUPPLEMENTARY NOTES

Presented at the U.S. Army Numerical Analysis and Computer Conference, Huntsville, AL, 26-27 Feb 81.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Moving Load
Beam Vibrations
Finite Element
Gun Dynamics
Projectile Eccentricity

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The finite element solution formulation in time- and space-coordinates is extended to beam vibrations effected by a moving couple. This problem has direct application to gun motions analysis with an unbalanced moving projectile. The moving load, instead of being a time-dependent Dirac delta function as for the case of a moving concentrated force, is now the derivative of this Dirac delta function. This singular function does not present any difficulty due to

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20. ABSTRACT (CONT'D)

the variational process employed. This solution procedure is described together with results of beam motions subjected to a couple moving with various speeds.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-81032	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): SAFE SERVICE LIFE TESTING OF THE 155 MM M185 HOWITZER BARREL WITH M203 PROPELLING CHARGE	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Bruce B. Brown and Howard D. McAlonie	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3111162223, PRON No. 1A0204811A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: August 1981
	13. NUMBER OF PAGES: 40
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Howitzer	Fatigue Test	Fracture Toughness
155 MM M185	Fatigue Life	Fatigue Failure
Cannon	Safe Service Life	
Barrel	Fatigue Crack	
Tube	Propelling Charge 155 mm M203	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A fatigue study has been made of the 155 mm M185 barrel operating at M203 propelling charge pressure to assess the safe fatigue life and determine failure locations and modes. Two regions were tested: the origin of rifling which proved critical, and the bore evacuator. Reliability factors were determined and a safe service life recommended.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-81033	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* PROCESS AND PROCEDURE GUIDE FOR THE "PUMP THRU" METHOD OF CHROMIUM PLATING 120 MM XM256 GUN BORES		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. D'Andrea, V. P. Greco, and J. Walden		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 32970672130 PRON No. 1A9241411A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE October 1981 13. NUMBER OF PAGES 90
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Plating	Guns
Chromium	"Pump Thru"
Controller	Computer
Process	Large Caliber
	Microprocessor

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The "pump thru" plating system to chromium plate large caliber guns is described. Included in this report are: a detailed explanation of the "pump thru" prototype plating facility, process equipment used, related specification requirements, and the process procedure for chromium plating the 120 mm cannon tube and chamber.

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20. ABSTRACT (CONT'D)

This computerized facility shows the ready availability of program substitution, accommodation of complex plating processes and removal of manual restraints through automation.

Typical chromium plating results of several 120 mm XM256 gun barrels are presented to show the capability of the automated "pump thru" facility. These results have arisen from increased monitoring and control capabilities, which are essential needs for the automated factory.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER ARLCB-TR-81034	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A NEW VARIATIONAL METHOD FOR INITIAL VALUE PROBLEMS, USING PIECEWISE HERMITE POLYNOMIAL SPLINE FUNCTIONS	5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen Julian J. Wu	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 PRON No. 1A1283121A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE August 1981 13. NUMBER OF PAGES 19
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

Presented at the US Army Numerical Analysis & Computers Conference, Huntsville, AL, 26-27 Feb 81.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Variational Principle
Initial Value Problems
Bilinear Concomitant
Adjoint System Far End Value
Spline Function
Finite Element
Recursive Solutions

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A variational principle for a functional can be found which satisfies both the original system and its adjoint system. The variations of this functional give no boundary terms if the bilinear concomitant of the systems vanishes. For a second order time varying initial value problem, one can adjust the boundary conditions of the adjoint system in terms of the boundary conditions of the original system so that the bilinear concomitant is identically zero.

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20. ABSTRACT (Cont'd)

An expression for the variation of the functional is derived which contains only the terms involving the variations of the adjoint variable and its derivative, but no variation of its second derivative. The variations of the adjoint variable and its derivative are found to be zeroes at the final conditions, just as the variations of the original variable and its derivative are zero at the starting (initial) conditions. This implies that we are able to solve the problem in one direction without worrying about the conditions at the other end as the initial value problem should be. The algorithm is much more simplified than in the past. An example is given to show the procedures of this new variational method.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-81035	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: ACTIVATION OF SUPERALLOYS AND STAINLESS STEELS FOR CHROMIUM PLATING	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): W. Baldauf, E. S. Chen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102T1600011, DA Project No. 1L161102AH60, PRON No. 1A0215601A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: August 1981
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18. SUPPLEMENTARY NOTES

Presented at Symposium on Plating on Difficult to Plate Metals, New Orleans, LA, 30-31 October 1980.
Published in proceedings of the symposium.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Activation
Adhesion
Chromium Plating
Electrodeposition
Stainless Steel
Superalloys

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The adhesion of electrodeposited chromium on cobalt, nickel and iron-nickel based superalloys such as CG-27, Haynes alloy 25, and Udimet 700, as well as stainless steels was investigated. A number of pretreatments were used to activate these alloys. The results show that a hydrofluoric-sulfuric acid pretreatment used anodically produces excellent adhesion. A qualitative adhesion test, named the "Groove Test" was developed to evaluate the adhesion of thick deposits of chromium on metallic substrates. The development of this test is described.

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1. REPORT NUMBER: ARLCB-TR-81036	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: AUTOMATED PLATING OF LARGE CALIBER GUNS - APPLICATION OF COMPUTER CONTROL TO "PUMP THRU" PLATING SYSTEMS	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Joseph A. Walden	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 32970672130, PRON No. 1A9241411A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: September 1981
	13. NUMBER OF PAGES: 198
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Plating	"Pump Thru"
Chromium	Computer
Controller	Large Caliber
Process	Microprocessor
Guns	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Computerized control of the "pump thru" plating system to chromium plate large caliber guns is described. Included in this report are: circuit diagrams of interfacing electrical hardware; ladder diagrams and memory address records; a detailed explanation of program operation, and a software stepper switch whose function can be automatically or manually controlled.

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20. ABSTRACT (Cont'd)

The study shows the ready availability of program substitution, accommodation of complex plating processes, and removal of manual restraints through automation. Typical chromium plating results of several 120 mm XM256 gun barrels are presented to show the capability of the automated "pump thru" facility. These results have arisen from increased monitoring and control capabilities, essential needs for the automated factory.

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1. REPORT NUMBER: ARLCB-TR-81037	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: FATIGUE PERFORMANCE COMPARISON OF ROTARY FORGED AND CONVENTIONALLY FORGED CANNON BARRELS (105 MM M68)	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Bruce B. Brown and Howard D. McAlonie	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3110.15.1100; PRON No. M7-T-F1811-01-M7-1A
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fatigue
Rotary Forge
Press Forge
Cannon Barrel
Fracture Toughness
105 mm M68
Fatigue Test

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Three 105 mm M68 barrels - two formed by the new rotary forge process at Watervliet Arsenal and one formed by the conventional forging process - were fired beyond the assigned safe life and hydraulically cycled to fatigue failure. Fracture toughness, mechanical property, and metallurgical evaluations were made to characterize the material. Test data was evaluated and compared with previous fatigue data on this barrel. No significant difference in fatigue performance or mechanical properties is noted between the two forging methods.

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1. REPORT NUMBER ARLCB-TR-81038	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ELASTIC-PLASTIC THICK-WALLED TUBES SUBJECTED TO INTERNAL PRESSURE AND TEMPERATURE GRADIENT		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H5710011 DA Project No. 1L161102BH57 PRON No. 1A1235821A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE September 1981 13. NUMBER OF PAGES 18
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18. SUPPLEMENTARY NOTES

Presented at 27th Conference of Army Mathematicians, US Military Academy, West Point, NY, 10-12 June 1981.
Published in proceedings of the conference.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Elastic-Plastic
Thick-Walled Tube
Finite-Difference Method
Internal Pressure
Temperature Gradient

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Using von Mises' criterion and the Prandtl-Reuss flow theory, numerical solutions are obtained for the stresses, strains, and displacements in an elastic-plastic thick-walled tube subjected to internal pressure and temperature gradient. The material is based on the incremental finite-difference method in conjunction with a scaled loading approach. All incremental quantities are determined in the program and no iteration is needed. The approach is simpler than others yet quite general and accurate.

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1. REPORT NUMBER ARLCB-TR-81039	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* FABRICATION AND CHARACTERIZATION OF TUNGSTEN WIRE REINFORCED U-0.75 Ti ALLOY COMPOSITES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) I. Ahmad, J. Barranco, (Cont'd on Reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 692000.071.0012 PRON No. 1A1263841ANF
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE September 1981 13. NUMBER OF PAGES 31
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

KE Penetrator	Reinforcement
Depleted Uranium	Composites
Tungsten Wires	Coextrusion

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Composites of U-0.75 Ti reinforced with 0.56 V_f tungsten wires have been fabricated by hydrostatically extruding alloy billets containing seven VM-E grade 6.2 mm (0.245 in.) diameter tungsten rods positioned in a hexagonally close-packed arrangement. Runs were made at 500°C and 600°C at an extrusion ratio of 9:1 to achieve nominally 9.6 mm (0.38 in.) diameter rod stock, which was machined into tensile, bend, compression, and Taylor specimens.

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7. AUTHORS (Cont'd)

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Aberdeen, MD

20. ABSTRACT (Cont'd)

Metallurgical examination of the transverse sections of the extruded specimens showed no detectable porosity or filament-matrix interaction. Mechanical property including Taylor test data are presented along with a disucssion of the failure modes observed in these various tests.

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1. REPORT NUMBER ARLCB-TR-81040	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ON ELASTIC-PLASTIC ANALYSIS OF AN OVERLOADED BREECH RING USING NASTRAN		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H5710011 DA Project No. 1L161102BH57 PRON No. 1A1235821A1A
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18. SUPPLEMENTARY NOTES

To be presented at Tenth NASTRAN Users' Colloquium, NASA/Jet Propulsion Lab, Pasadena, California, 7-9 October 1981.
To be published in proceedings of the colloquium.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Elastic-Plastic
Breech Ring
Finite Element
NASTRAN Code

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The piece-wise linear analysis option of the NASTRAN code was used to analyze a photoplastic model for sliding breech mechanism. A two-dimensional finite element representation for the breech ring was chosen and the material was made of polycarbonate resin. The aluminum block was regarded as rigid and the width of contact was assumed to remain unchanged during loading. The displacements and stresses in the breech ring were obtained for loading in
(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

the elastic as well as plastic range. The maximum tensile stresses before and after complete unloading were obtained and compared with numerical and experimental results.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-81041
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): FRACTURE TOUGHNESS OF 105mm M68 TUBES

5. TYPE OF REPORT & PERIOD COVERED: Final

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): F. A. Heiser

8. CONTRACT OR GRANT NUMBER(s):

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Electro Slag Refining
Fracture Toughness
105mm M68
Rotary Forging

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):
Since fracture toughness is not usually measured, a program was initiated to measure K_{Ic} of 105mm M68 cannon tube forgings produced by various combinations of steel producer, steel making technique, and forging technique. The data show that, regardless of the techniques used to produce the forging, the fracture toughness is consistently higher at the breech end than at the muzzle end, a pattern which is consistent with the Charpy V-Notch (CVN) energy which is measured as part of the acceptance testing of tube forgings.
(CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

This is interpreted as a manisfestation of the increased forging reduction seen at the muzzle end.

It is also shown that fracture toughness is greatly influenced by the steel making practice and by the steel supplier, but it is not greatly affected by the forging process used. Specifically, the fracture toughness of rotary forged tubes is similar to that of conventionally press forged tubes, when the steel making practice is the same, and the forging reduction is similar. Of the mechanical properties usually measured, only CVN shows a relationship to fracture toughness. Even then, there is sufficient scatter to preclude using CVN as a predictor.

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4. TITLE (and Subtitle) 155mm M199 FIRING TRAIN TEST		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. Fiscella R. Carroll		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research and Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 32111600156 PRON No. 1A9280051A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Energy
Firing Mechanism
Firing Pin
Misfire
Primer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Due to misfire problems during the Follow-on Evaluation (FOE) of the 155mm M198 Howitzer, an investigation was initiated to determine what extent increasing the energy supplied by the M199 firing train would have on improving the system performance with marginal M82 primer lots (or with marginal M35 firing mechanisms). It was concluded that increasing the amount of energy transferred to the primer has a significant effect in lowering the misfire rate.

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1. REPORT NUMBER ARLCB-TR-81043	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* METHOD OF SOLUTION FOR VARIATIONAL PRINCIPLE USING BICUBIC HERMITE POLYNOMIAL		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 PRON No. 1A1283121A1A
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18. SUPPLEMENTARY NOTES

Presented at 27th Conference of Army Mathematicians, US Military Academy, West Point, NY, 10-12 June 1981.
Published in proceedings of the conference.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Variational Principle
Initial-Boundary Value Problem
Bilinear Concomitant
Adjoint System
Spline Function
Recursive Solution
Bicubic Hermite Polynomial

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

In solving mixed boundary and initial value problems of a second order partial differential equation using spline functions, the computation may be simplified considerably if the variable in time can be truncated into arbitrary sections. Each section may have several node points for the spline functions in the time domain. This is true because we found from a previous paper[1] that the initial value problem can be solved in one direction using variational principle and

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20. ABSTRACT (CONT'D)

cubic Hermite Polynomials, without worrying about the conditions at the other end.

The end conditions of the adjoint system can be adjusted according to the end conditions of the original system so that the bilinear concomitant is identically zero. This satisfies the variational principle. A bilinear form of the original and adjoint variables is employed in determining the coefficients of the variations of the functions and their first derivatives. There is no term involving the variations of any higher derivatives. A bicubic Hermite Polynomial spline function is used which gives continuity in the function and first partial derivatives in space or time, together with the mixed first partial derivative in space and time. Algorithm and procedure of computation are given.

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1. REPORT NUMBER: ARLCB-TR-81044	2. GOVT ACCESSION NO.
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4. TITLE *(and Subtitle)*: THERMO-ELASTIC-PLASTIC STRESSES IN MULTI-LAYERED CYLINDERS	5. TYPE OF REPORT & PERIOD COVERED
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7. AUTHOR(s): John D. Vasilakis	8. CONTRACT OR GRANT NUMBER(s)
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Presented at 27th Conference of Army Mathematicians, US Military Academy, West Point, NY, 10-12 June 1981.
Published in proceedings of the conference.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Thermo-Elastic-Plastic Response
Multi-Layered Cylinders
Thermal Loads
Pressure Loads

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

One of the many efforts undertaken to increase the life of gun tubes and/or increase their resistance to erosion involves the use of liners fabricated from different materials. A finite difference computer code for investigating the thermo-elastic-plastic response of gun tubes has been expanded to include multi-layered cylinder response to time dependent boundary conditions. Considered are both cyclic heat input and cyclic stress input. Response

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20. ABSTRACT (Cont'd)

curves from inputs representative of repeated firing cycles are presented. The emphasis in this report is on the transient temperature response and on the thermo-elastic stresses and mechanical stresses in the layers.

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: SUPERCONDUCTIVITY IN HYDROGEN-CHARGED COPPER-IMPLANTED PALLADIUM	5. TYPE OF REPORT & PERIOD COVERED: FINAL
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): A. Leiberich, W. Scholz, W. J. Standish, and C. G. Homan (CONT'D ON REVERSE)	8. CONTRACT OR GRANT NUMBER(s): AMCMS NO.611102H600011; PRON No.1A1283121A1A
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18. SUPPLEMENTARY NOTES

Presented at Third Ion Beam International Meeting, Grenoble, France, September 1981. To be published in the Journal of Physics, A.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Superconductivity
Ion Implantation
Palladium-Copper Hydride

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A superconducting transition temperature, T_c, of 124. K has been observed in palladium implanted with copper ions and electrolytically charged with hydrogen at dry ice temperature. A step-wise warmup procedure between 77 K and 273 K produces considerable variations in T_c. Annealing the copper implanted palladium before electrolysis does not change T_c to a substantial degree.

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7. AUTHOR(S)

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Large Caliber Weapon Systems Laboratory
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1. REPORT NUMBER: ARLCB -TR-81046	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: STUDY OF EROSION RESISTANT MATERIALS FOR GUN BORES PART III: LOW CONTRACTION (LC) CHROMIUM PLATED LINERS	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): R. L. Cullinan, G. D'Andrea, P. Croteau	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No.6436280070012 PRON No. 1A1246361A1A
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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Gun Tube Erosion	Low Contractile Chromium
Shrunk-Fit Liner	Erosion Protection
Bore Plating	20 mm M24A1 Gun

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The major criteria for the condemnation of gun tubes is based on the excessive erosion of the bore which results in loss of range and accuracy. Gun tube erosion is caused by a number of severe thermal, mechanical, and chemical factors interacting during the firing cycle. One approach to minimize erosion is to line gun barrels with wear resistant materials. This work introduces LC chromium coated steel liners to reduce excessive bore erosion. Firing tests

(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

conducted in the 20 mm M24A1 gun system compare the LC Cr/steel with conventional (hard) chromium plated steel liners subjected to the same test conditions. Preliminary tests indicate that the LC Cr/steel combination reduces erosion in the 20 mm gun system.

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